Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of	
Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act	GN Docket No. 16-245

COMMENTS OF NEW AMERICA'S OPEN TECHNOLOGY INSTITUTE

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INTRODUCTION AND SUMMARY

OTI files these comments in response to the *Twelfth Broadband Progress Notice of Inquiry*.[1] The Federal Communications Commission ("FCC") is charged, through Section 706, with annually determining whether "advanced telecommunications capability" is being deployed "on a reasonable and timely basis . . . to all Americans."[2] In the *Notice of Inquiry*, the FCC asks questions about the proper speed (or "throughput") benchmarks for fixed and mobile broadband, how to measure broadband capabilities, and whether the FCC should include non-throughput characteristics (latency) and data caps in its measurement of "advanced" telecommunications (or broadband).

OTI recognizes and appreciates the work the FCC has done in the past to increase the throughput benchmarks for broadband. The increase to 25 Mbps download and 3 Mbps upload ("25/3") in 2015 was a very important improvement. However, the time has come to reconsider those benchmarks in light of new technology. Thus, OTI makes the following arguments: the FCC should (1) increase its fixed broadband throughput benchmarks to reflect the bandwidth requirements of new applications; (2) measure broadband throughput in a way that is most reflective of the end user experience; (3) adopt non-throughput metrics that trigger a broader investigation into whether the connection is "advanced," and (3) incorporate data caps as a factor in the Section 706 analysis. Lastly, OTI argues that advanced telecommunications services are not being deployed in a reasonable and timely manner to all Americans.

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[1] *Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, Twelfth Broadband Progress Notice of Inquiry*, GN Dkt. 16-245, FCC 16-100 (Aug. 4, 2016), https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-100A1.pdf ("NOI").

[2] 47 U.S.C. § 1302.

Notably, the purpose of this proceeding is to define what constitutes *advanced* telecommunications service in Section 706, which should be a forward-looking definition. This does not and should not prevent the FCC from establishing different benchmarks in other proceedings where circumstances call for it. For instance, the FCC set a different benchmark in the Lifeline context (10 Mbps download and 1 Mbps upload) to account for other considerations such as cost of connectivity for low-income consumers. OTI is committed to ensuring robust and affordable Internet for all. OTI understands the need for a variety of methods for provisioning broadband in the immediate term, while we continue to work as a country toward access in the speeds and other characteristics proposed in these comments.

I. The FCC should increase its broadband benchmark to 50 Mbps download and 20 Mbps upload with a plan to reach a symmetrical benchmark in the near future.

Telecommunications technology is improving and evolving every year. Throughput offered by Internet service providers continues to increase, with many ISPs offering gigabit connections in certain areas. The FCC's National Broadband Plan (the "Plan") predicted these changes and set a forward-looking goal of getting 100 million homes connected to broadband of 50 Mbps download and 20 Mbps upload by 2015 ("50/20").[3] It set a further goal of getting 100 million homes connected to broadband of 100 Mbps download and 50 Mbps upload by 2020.[4] The FCC should increase its benchmarks to comport with the Plan's goals.

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[3] National Broadband Plan, FCC, at 9, https://transition.fcc.gov/national-broadband-plan/national-broadband-plan.pdf (the "Plan").
[4] *Id.*

A.   Online services increasingly require higher throughput.

The FCC should increase its broadband throughput benchmarks because ISPs increasingly offer faster throughput[5] and the apps and services that travel over the Internet are increasingly high-bandwidth.

The FCC's benchmarks should be sufficient for households to use high-bandwidth apps and services without performance issues.[6] Every day there are new services for users to take advantage of, many of which require a significant amount of bandwidth. The FCC points to several of them throughout its NOI, including 4K television, VoIP, video conferencing, online gaming, VPN platforms, streaming video, telehealth, and other interactive services.[7] In today's hyper-connected world, families could be running up to 13 connected devices at the same time; some may use it for homework, others for entertainment (e.g., streaming video or video games), communication, health, and other reasons.[8] As such, bandwidth use adds up.[9] To accommodate all these uses, the FCC's benchmark should be increased to 50/20.

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[5] NOI, ¶ 15 (describing how ISPs are increasingly providing faster throughput than the current 25 Mbps download/3 Mbps upload benchmarks). These speeds will likely continue to increase, especially in markets with actual competition such as those with municipal broadband networks or those with smaller ISPs such as Sonic Net and Google Fiber. *See* Bryan Clark, *Comcast hopes you don't notice it's twice as expensive in non-Google Fiber markets*, Next Web (Aug. 23, 2016), http://thenextweb.com/insider/2016/08/22/comcast-hopes-you-dont-notice-its-twice-as-expensive-in-non-google-fiber-markets.

[6] *See* Appendix A for a chart of throughput and latency requirements for many of today's online services, including augmented reality, virtual reality, real-time gaming, and a multi-person video call.

[7] NOI, ¶¶ 17, 40-44.

[8] Victor Thomson, *How Internet-Connected Devices Have Changed the Household*, iTechPost (June 14, 2016), http://www.itechpost.com/articles/20699/20160614/internet-connected-devices-changed-household.htm.

[9] *How Much Internet Speed Do I Really Need*, OTT Communications (Dec. 23, 2015), http://www.ottcommunications.com/how-much-internet-speed-do-i-really-need.

Likely the most common use of a home broadband connection is online video, which has exploded over the past several years as bandwidth has increased and the ability to make videos and upload them to the Internet has become easier.[10] But viewing these and other videos takes a significant portion of a 25 Mbps download home broadband connection. Netflix recommends a 5 Mbps download speed to stream a single 1080p video.[11] If two people in the same household are simultaneously watching Netflix, then the bandwidth use doubles to 10 Mbps. If a person watches a 4K video from Netflix, then that single video stream likely takes up the entire 25 Mbps connection.[12] Hulu recommends at least a 1.5 Mbps download speed for 480p video, and 3 Mbps for 720p.[13] YouTube recommends at least a 1 Mbps download speed to view "premium" content (such as movies, TV shows, and live events).[14] HBO Go recommends 3 Mbps download speed.[15] As video quality continues to increase, and as online services move toward offering 1080p or even 4K video, these numbers will only rise.

Other high-bandwidth services stream directly to devices as well. For instance, video conferencing (such as over Skype or Google Hangouts) requires 1.2 Mbps download speeds for a

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[10] Amanda Walgrove, *The Explosive Growth of Online Video, in 5 Charts*, Contently (July 6, 2015), https://contently.com/strategist/2015/07/06/the-explosive-growth-of-online-video-in-5-charts.
[11] Internet Connection Speed Recommendations, Netflix Help, https://help.netflix.com/en/node/306.
[12] *Id. See also* Dan Rayburn, *The Adoption of 4K Streaming Will Be Stalled By Bandwidth, Not Hardware & Devices*, Streaming Media Blog (Jan. 14, 2015), http://blog.streamingmedia.com/2015/01/4k-streaming-bandwidth-problem.html (bandwidth constraints are slowing the deployment of 4K technology).
[13] Hulu Subscription System Requirements, Hulu Help, https://help.hulu.com/articles/197541.
[14] System Requirements, YouTube Help, https://support.google.com/youtube/answer/78358?hl=en.
[15] *Video is blurry, pixelated, or poor quality on my computer*, HBO Go Help Center, https://help.hbogo.com/hc/en-us/articles/204871467-Video-is-blurry-pixelated-or-poor-quality-on-my-computer-.

one-to-one call.[16] As more people join the video conference, more bandwidth is required. Skype

says that a group video call of five people would require 2 Mbps, and a group video call of seven

people would require 4 Mbps.[17] Streaming music apps, like Spotify, use approximately 0.32 Mbps

for high quality music.[18]

Video gaming also takes up significant bandwidth and is increasingly popular.[19] Sony has

long recommended a minimum throughput of 5 Mbps for its Playstation Now service for

Playstation 4,[20] and recommends the same throughput threshold for when Playstation games

become playable on a Personal Computer.[21] Microsoft recommends a minimum connection of 1.5

Mbps for Xbox One.[22] That said, the Xbox One is a multimedia platform; to watch high quality

videos through it, the consumer will need much more bandwidth than that. This will certainly be

true for the new Xbox One S, which has 4K capability.[23]

Similarly, all software, including video games and patches for those games, and music are

increasingly being distributed via download rather than by Compact Disc or other physical

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[16] How Much Bandwidth Does Skype Need?, Skype Help,
https://support.skype.com/en/faq/FA1417/how-much-bandwidth-does-skype-need.
[17] *Id.*
[18] *What Bitrate Does Spotify Use for Streaming?*, Spotify Help,
https://support.spotify.com/us/article/What-bitrate-does-Spotify-use-for-streaming.
[19] The Entertainment Software Association found that 42 percent of Americans play video games
for more than three hours per week. Colin Campbell, *Here's how many people are playing games
in America*, Polygon (Apr. 14, 2015), http://www.polygon.com/2015/4/14/8415611/gaming-stats-
2015.
[20] Luke Karmali, *PlayStation Now Recommends 5mb/s Connection*, IGN (Jan. 9, 2014),
http://www.ign.com/articles/2014/01/09/playstation-now-requires-5mbs-connection.
[21] Matt Peckham, *Sony Is About to Turn PCs into PlayStations*, Time (Aug. 23, 2016),
http://time.com/4461767/sony-playstation-ps-now-pc-windows.
[22] *Troubleshoot slow game or app downloads on Xbox One*, Xbox Help,
http://support.xbox.com/en-US/xbox-one/networking/troubleshoot-slow-game-or-app-
downloads-on-xbox-one.
[23] Xbox One S, http://www.xbox.com/en-US/xbox-one-s.

medium, requiring fast download throughput to avoid slow downloads and upset customers.[24]

Steam, released in the early 2000s, has gained significant popularity, and it distributes video

games via download. Other large companies like Electronic Arts and Blizzard Entertainment have

followed with their own platforms for game downloads, Origin and Battle.net Desktop App

(respectively). The files themselves for these games are very large and could take a long time to

download on a slower connection. For instance, DOOM (released this year) is 45 GB.[25] Uncharted 4

is 50 GB with a 5 GB patch.[26] Microsoft Office is also distributed online through a download.[27]

Further, music is increasingly purchased and downloaded (or streamed, as mentioned above)

online via iTunes, Google Play Store, and other services.[28]

Two nascent but emerging high-bandwidth technologies include virtual reality ("VR") and

augmented reality ("AR").[29] ARRIS, a communications technology company, states that

competition for bandwidth in the home is intense, and VR will be the "next major bandwidth-

consuming application."[30] ARRIS has estimated that a 720p VR game will require at least a 50

[24] Matt Smith, *Discs Are Dying! How to Live Without a CD or DVD Drive in your Laptop*, Digital Trends (Apr. 24, 2013), http://www.digitaltrends.com/computing/discs-are-dying-how-to-live-without-a-laptop-optical-drive; *Why the Audio CD IS Dying … and What Will Replace It*, Pfeiffer Consulting (2007), http://www.pfeifferreport.com/trends/Pfeiffer_Music_Rep.pdf.
[25] Steve Kota, *Top Five Video Games of 2016 How Much Bandwidth Is Required To Play?*, Rhoonet, https://www.rhoonet.com/top-five-video-games-2016-much-bandwidth-required-play.
[26] *Id.* If the consumer has a data cap, this one download could consume a significant portion of it.
[27] Office 365 Frequently Asked Questions, Microsoft, https://products.office.com/en-us/microsoft-office-for-home-and-school-faq#downloadInstall-section.
[28] Derek Thompson, *The Death of Music Sales*, Atlantic (Jan. 25, 2015), http://www.theatlantic.com/business/archive/2015/01/buying-music-is-so-over/384790.
[29] Some VR and AR will take place over cellular networks, but to the extent they take place over Wi-Fi networks connected to a residential connection, their bandwidth requirements are relevant for fixed broadband benchmarks.
[30] *ARRIS Gives Us a Hint of the Bandwidth Requirements for VR*, Online Reporter (June 17, 2016), http://www.onlinereporter.com/2016/06/17/arris-gives-us-hint-bandwidth-requirements-vr.

Mbps connection, and a 4K VR game will require up to 500 Mbps.[31] Based on this information,

ARRIS's CTO predicted that VR will be a significant driver of gigabit connections.[32] Some say that

VR will not work with 4G connections but will require 5G.[33] YouTube has estimated that 360 degree

videos, which can provide the basis for VR, require 4-5 times as much bandwidth as other

YouTube videos.[34] And, much like video games and other software, VR games require large file

downloads, anywhere from 10 GB to 60 GB and likely more as the technology grows.[35] In much the

same way, augmented reality requires high bandwidth; by some estimates over 100 Mbps.[36]

The growth of the Internet of Things ("IoT"), where appliances and other household items

are constantly connected and transferring data, will also increase broadband usage—something

the FCC has already recognized in the mobile context.[37] The general consensus around IoT is that,

with potentially billions of new devices connecting to the Internet via Wi-Fi or cellular signals,

capacity will need to increase.[38]

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[31] *Id.*

[32] *Id.*

[33] *See Virtual Reality: The Reality for Connectivity Providers*, Telecoms.com (Jan. 15, 2016), http://telecoms.com/opinion/virtual-reality-the-reality-for-connectivity-providers, and *Greenlight VR Provides State of the VR Industry at NAB Show*, Greenlight Insights (Apr. 2016), http://greenlightinsights.com/2016/04/18/greenlight-vr-provides-update-nab-show.

[34] Sean Hollister, *YouTube's Ready to Blow Your Mind with 360 Degree Videos*, Gizmodo (Mar. 13, 2015), http://gizmodo.com/youtubes-ready-to-blow-your-mind-with-360-degree-videos-1690989402.

[35] *ARRIS Gives Us a Hint of the Bandwidth Requirements for VR*, Online Reporter (June 17, 2016), http://www.onlinereporter.com/2016/06/17/arris-gives-us-hint-bandwidth-requirements-vr.

[36] *Understanding 5G: Perspectives on Future Technological Advancements in Mobile* at 9, GSMA Intelligence (Dec. 2014), https://www.gsmaintelligence.com/research/?file=141208-5g.pdf&download ("*Understanding 5G*").; *see also* Kannon Yamada, *Augmented Reality Apps: Useful, or Just Hype? MakeUseOf Tests*, MakeUseOf (Mar. 5, 2013), http://www.makeuseof.com/tag/augmented-reality-apps-useful-or-just-hype-makeuseof-tests (describing an AR app using 5-6 times more data than non-AR apps).

[37] NOI, ¶ 42.

[38] *Spectrum for the Internet of Things Needs to Be Carefully Considered*, GSMA (Apr. 20, 2016), http://www.gsma.com/newsroom/blog/spectrum-internet-things-needs-carefully-considered;

People use their connections for many reasons, and often multitask. It is easy to see how multiple people with multiple devices engaging in multiple online activities on the same residential connection can quickly lead to buffering, slow load times, and frustration even with a 25/3 connection. A broadband connection meeting the FCC's benchmark should not be so easily bogged down by a few simultaneous and common uses.

Next year, there will be new technologies available, and the technologies discussed above will be even more ubiquitous. In anticipation of that progress, the FCC should take this opportunity to increase the fixed throughput benchmarks for advanced services to 50/20 with a plan to meet the Plan's goals by 2020 or soon thereafter.

B.   Even if the FCC decides not to increase the download throughput benchmark, it should still increase upload throughput to 20 Mbps with a plan to reach a symmetrical definition.

Upload speeds matter, too.[39] The Internet is a two-way communications medium. Uploading is how consumers exercise the vital First Amendment rights that the Internet facilitates. From the simple comment on a news article to the more bandwidth-intensive uploading a video showing police use of excessive force[40] or live streaming yourself playing video games or playing music to earn a livelihood,[41] upload throughput is essential to online communication,

Chris Neiger, *Could Bandwidth Problems Derail the Internet of Things?*, Motley Fool (June 21, 2014), http://www.fool.com/investing/general/2014/06/21/could-bandwidth-problems-derail-the-internet-of-th.aspx.

[39] Chris Hoffman, *HTG Explains: Should You Pay More for a Faster Internet Connection?*, How-to Geek, http://www.howtogeek.com/217627/htg-explains-should-you-pay-more-for-a-faster-internet-connection.

[40] Doug Saunders, *Video showing apparent use of force by San Bernardino police surfaces*, San Bernardino Sun (May 1, 2015), http://www.sbsun.com/government-and-politics/20150501/video-showing-apparent-use-of-force-by-san-bernardino-police-surfaces.

[41] *See* Jay Egger, *How exactly do Twitch streamers make a living? Destiny breaks it down*, Daily Dot (Apr. 21, 2015), http://www.dailydot.com/esports/twitch-streaming-money-careers-destiny.

participation in society, and taking advantage of the myriad online services that require fast

upload capability.

The FCC's current upload benchmark, which allows for two simultaneous Skype calls at

most,[42] is insufficient for today's networks and uses. Upload benchmarks should reflect, as with

download benchmarks, that multiple people in a household may upload data at the same time.[43]

Further, the ultimate goal for *advanced* telecommunications benchmarks should be symmetrical

download/upload throughput.[44] For now, the FCC should match the Plan's 20 Mbps goal.[45]

Uploading content to the Internet has become a common occurrence for everyday users.

Upload requirements are increasing as smartphones contain very powerful cameras, video

cameras, and are constantly-connected and encourage consumers to upload files for a variety of

reasons, such as communicating with friends and even to monitor their health.[46] The very purpose

of social media platforms is for users to upload and share experiences. Facebook and Instagram

allow users to upload photos and videos. YouTube allows users to upload videos. Consumers rely

on these services to communicate and share with friends, family, and others. Similarly, cloud

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[42] NOI, ¶ 18.

[43] *See* NOI, ¶ 13 ("Our current observations are that download speeds of 25 Mbps allow a *household* to access a range of bandwidth intensive services . . . simultaneously over multiple devices.").

[44] Some ISPs already provide symmetrical throughput. *See, e.g.*, Electric Power Board of Chattanooga, https://epb.com/home-store/internet; Verizon FiOS, http://www.verizon.com/home/fios-fastest-internet.

[45] New cable technology, DOCSIS 3.1, is capable of upload throughput at 1 Gbps, so the proposed increase in this comment is reasonable and leaves plenty of room for future increases as upload capability becomes even more important. *New Generation of DOCSIS Technology*, CableLabs, http://www.cablelabs.com/news/new-generation-of-docsis-technology.

[46] See, for instance, Microsoft HealthVault, which can connect to tracking devices and send health data to the cloud. *How it Works*, HealthVault, https://www.healthvault.com/us/en/Howitworks; *see also* Jill Duffy, *10 Apps That Are Changing Healthcare*, PC Magazine (Feb. 11, 2015), http://www.pcmag.com/article2/0,2817,2476623,00.asp (listing other health apps).

storage also requires fast upload throughput, especially as consumers turn to cloud storage

services to backup significant amounts of data.[47] Cloud storage has become extremely popular and

is generally predicted to expand greatly over the coming years.[48] Uploading files to these services

in a reasonably fast manner requires robust upload capability.

Several live-streaming websites exist as well, such as Periscope, Facebook Live, and

Twitch. These sites require constant upload capability because the streams may last for hours.

Such upload capability may even be used for political transparency and accountability. Recently,

the Democrats in the House staged a sit-in while they asked for a vote on gun control, and when

traditional video broadcast tools failed, Periscope and Facebook Live allowed members of

Congress and their staff to protest directly, and C-SPAN ended up relying on those broadcasts to

show the sit-in.[49] Slow upload throughput may jeopardize similar future uses and the livelihood of

those who rely on streaming to earn their living.[50]

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[47] *Computer Backup Systems Buying Guide*, Consumer Reports (Apr. 2016),
http://www.consumerreports.org/cro/computer-backup-systems/buying-guide.htm (discussing
cloud storage options up to 4 TB).
[48] Justin Kaplan, *Growth in Consumer Cloud Storage Drives Investment Opportunities*, Penn
Mutual (May 21, 2015), https://blog.pennmutualam.com/growth-in-consumer-cloud-storage-
drives-investment-opportunities; *Cisco Global Cloud Index: Forecast and Methodology, 2014–2019
White Paper*, Cisco (Apr. 21, 2016),
http://www.cisco.com/c/en/us/solutions/collateral/service-provider/global-cloud-index-
gci/Cloud_Index_White_Paper.html; Gunner Thorne, *Gartner Predicts Massive Growth of
Consumer Cloud Storage*, Online File Storage (Sept. 5, 2015),
http://www.onlinefilestorage.com/gartner-predicts-consumer-cloud-1520; Crystal Nichols, *Growth
of the Consumer Data Cloud*, Unitiv (Jan. 7, 2013), http://www.unitiv.com/it-solutions-
blog/bid/93223/Growth-of-the-Consumer-Data-Cloud.
[49] Kate Conger, *House Democrats broadcast sit-in on Periscope and Facebook Live*, TechCrunch
(June 22, 2016), https://techcrunch.com/2016/06/22/house-democrats-broadcast-sit-in-on-
periscope-and-facebook-live.
[50] Jay Egger, *How exactly do Twitch streamers make a living? Destiny breaks it down*, Daily Dot
(Apr. 21, 2015), http://www.dailydot.com/esports/twitch-streaming-money-careers-destiny.
Further, Amazon recently purchased Twitch.tv for $970 million, Eugene Kim, *Amazon Buys Twitch*

C. Throughput should be measured by examining the end user's average experience and not a theoretical maximum on the ISP's best day.

When measuring throughput of a given connection, the FCC should ensure that the measurement reflects the end user's average experience. Ookla's Speedtest.net, for example, uses a multi-threaded approach, which has a "higher tolerance for background packet losses, and can obfuscate deficiencies in the connection. Thus, multi-threaded testing is distorted towards better performance read-outs compared to normal browsing behavior on congested" connections.[51]

Other measurement tools capture a more realistic representation of the end-user experience. For instance, Measurement Lab ("M-Lab") hosts the Network Diagnostic Test ("NDT"), which measures broadband throughput (among other quality of service metrics) in the US and globally.[52] NDT tests a connection by sending "as much data as possible over a single connection to a server."[53] M-Lab's servers are located within Tier 1 datacenters, connected to the same Internet transit providers that ISPs interconnect with to provide Internet access to their customers. Therefore, NDT tests measure performance across network boundaries, providing measurement of the full network path used by consumers. M-Lab's choice in infrastructure placement at interconnection points allows M-Lab NDT test data to be separated by ISP and backbone/transit provider. M-Lab's NDT tests are likely to be closer to what the end user actually experiences, and the FCC's measurements should aspire to be similarly reflective of end user experience.

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for $970 Million in Cash, Business Insider (Aug. 25, 2014), http://www.businessinsider.com/amazon-buys-twitch-2014-8.
[51] Emily Hong & Sarah Morris, *Getting Up to Speed: Best Practices for Measuring Broadband Performance* at 10, New America's Open Technology Institute (June 2016), https://na-production.s3.amazonaws.com/documents/MeasuringBroadband.pdf ("*Getting Up to Speed*").
[52] NDT (Network Diagnostic Test), Measurement Lab, https://www.measurementlab.net/tools/ndt.
[53] *Getting Up to Speed*, at 9.

M-Lab hosts other tools as well, such as "MobiPerf," a mobile performance tool.[54] There are

also mobile-friendly implementations of NDT such as Measurement Kit.[55] M-Lab uses the data in a

variety of ways, including to create data visualizations.[56] The data often goes back several years

(NDT's dataset goes back to 2009) and is available at www.measurementlab.net.

II. The FCC should adopt a fixed broadband latency threshold that would trigger a broader investigation into quality of service.

Advanced telecommunications service should require consistently high-quality service. A

consumer's Internet experience will depend on more than simple data throughput.[57] In fact,

connections that meet the throughput threshold but are plagued with high latency, packet loss, or

jitter will still be detrimental to the consumer experience and should not be considered

"advanced" by the FCC.[58]

The FCC should set a latency threshold of 50 ms.[59] Connections measuring latency at more

than 50 ms should trigger a broader investigation into other service consistency metrics such as

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[54] MobiPerf, Measurement Lab, https://www.measurementlab.net/tools/mobiperf.
[55] Measurement Kit, GitHub, https://github.com/measurement-kit/measurement-kit.
[56] Visualizations of Network Performance, Measurement Lab, https://www.measurementlab.net/visualizations.
[57] Prior OTI comments cited to interconnection disputes between ISPs, transit networks, and content providers that caused connections to be unusable via latency and packet loss issues. Reply Comments of OTI, *Tenth Broadband Progress Notice of Inquiry*, at 3-4, GN Dkt. 14-126 (Sept. 19, 2014), https://ecfsapi.fcc.gov/file/7522902977.pdf.
[58] One consequence of the FCC establishing throughput benchmarks but not latency benchmarks is that network engineers may design and deploy networks that have too high latency, but have a high throughput due to the throughput/latency tradeoff. *See* Leonard Kleinrock, *The Latency/Bandwidth Tradeoff in Gigabit Networks*, IEEE Communications Magazine (Apr. 1992), http://cseweb.ucsd.edu/groups/csag/html/projects/Optiputer/Gigabit_Latency_Kleinrock.pdf. High latency can render the network unusable for real-time communication, even when that network is meeting the throughput benchmarks. Establishing standards for both will ensure that an important form of consumer harm is not ignored or forgotten.
[59] See Appendix A for a list of services that require very fast latency, including real-time gaming and multi-person video call, both of which require 10 ms.

packet loss and jitter. Many of the services that require fast throughput described above also require low latency. The ultimate goal for many applications is zero latency because high latency has a negative effect on the user's experience and can cause dissatisfaction.[60] For instance, multiplayer online video games seek to minimize latency. While different games can accept different round-trip times, some studies have concluded that 45-60 ms "are better estimates at how much latency is acceptable in the most fast-paced games than the traditionally quoted 100ms value."[61]

Virtual reality is extremely sensitive to latency. The purpose of virtual reality is to give the user a life-like experience in a virtual world. To be "nearly indistinguishable from reality," some say that a VR system would have to have 15 ms or even 7 ms delay.[62] Right now, the Oculus Rift can achieve approximately 30-40 ms latency under "perfectly optimized conditions."[63] Others have found that a "total system latency of 50 milliseconds will feel responsive, but still noticeably laggy" and "20 milliseconds or less will provide the minimum level of latency deemed acceptable."[64]

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[60] *See* Peter Mastin, *How Latency Is Killing Online Gaming*, Venture Beat (Apr. 17, 2016), http://venturebeat.com/2016/04/17/how-latency-is-killing-online-gaming (describing even short wait times and small delays leading to dissatisfied customers).
[61] Kjetil Raaen & Tor-Morten Gronli, *Latency Thresholds for Usability in Games: A Survey* (2014), at 9, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=10&ved=0ahUKEwjo5uiR6 vXOAhXF7SYKHTW5Al4QFghqMAk&url=http%3A%2F%2Fojs.bibsys.no%2Findex.php%2FNIK%2 Farticle%2Fdownload%2F9%2F6&usg=AFQjCNG3FKsoYpYWztcPW59SrpRcFk_PQg&bvm=bv.1317 83435,d.eWE&cad=rja.
[62] Kyle Orland, *How Fast Does "Virtual Reality" Have to Be to Look Like "Actual Reality"?*, Ars Technica (Jan. 3, 2013), http://arstechnica.com/gaming/2013/01/how-fast-does-virtual-reality-have-to-be-to-look-like-actual-reality.
[63] *Id.*
[64] *John Carmack's Delivers Some Home Truths on Latency*, Oculus Rift Blog, http://oculusrift-blog.com/john-carmacks-message-of-latency/682.

Setting the benchmark at 50 ms is reasonable. Cisco's Cloud Readiness Tool measures the

average latency in the U.S. at 42 ms, and the median at 23 ms.[65] With the median that much lower

than the mean, it is likely that a small number of very high latency measurements are pushing the

average up—likely from satellite providers.[66] Most connections will be below the 50 ms mark and

should not lead to unreasonable burdens for most providers.

As with throughput, there are many external sources the FCC can consult in measuring

and further understanding latency and other quality of service metrics. NDT, hosted by M-Lab,

measures latency, packet loss, and jitter in the US and globally.[67]

III. The FCC should pay close attention to mobile connections and should consider establishing a throughput goal of 10 Mbps download and 1 Mbps upload.

Mobile connections are fundamentally different than fixed connections, and measuring

mobile connections is correspondingly different on wireless versus wired networks. Mobile is

much less likely to handle the bandwidth-intensive applications and services described above, at

least not without nationwide 5G implementation.[68] While 4G "Advanced" technology is

theoretically capable of 1 Gbps throughput,[69] actual user experience will vary dramatically and

will likely be much lower than the theoretical maximum of 1 Gbps. Further, signals degrade based

on distance from a tower, signal strength, and physical barriers.[70]

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[65] Cisco Cloud Readiness Tool, Cisco, http://www.cisco.com/c/en/us/solutions/service-provider/cloud-readiness-tool/index.html.
[66] Jon Brodkin, *Satellite Internet faster than advertised, but latency still awful*, Ars Technica (Feb. 15, 2013), http://arstechnica.com/information-technology/2013/02/satellite-internet-faster-than-advertised-but-latency-still-awful.
[67] NDT (Network Diagnostic Test), Measurement Lab, https://www.measurementlab.net/tools/ndt.
[68] *See* Appendix A.
[69] *Understanding 5G*, at 11.
[70] *Getting Up to Speed*, at 18.

Thus, methodologies for measuring mobile broadband should be end-to-end, consistent, specific, and clear to avoid dramatically inconsistent results from test to test. Assuming the FCC can establish such a specific and consistent mobile measurement test, then it would be appropriate to adopt a metric such as 10 Mbps download and 1 Mbps upload, which has been supported by numerous parties in previous proceedings.[71]

IV.   **Data caps should factor into the FCC's Section 706 analysis and any benchmark should be continually reassessed and increased to account for new data-intensive services.**

Data caps disincent full use of a broadband connection and can lead to additional consumer harms, such as a tendency to install device and software updates less frequently.[72] Whether the cap comes in the form of charging for overages, throttling all traffic to very slow speeds, or something else, going over a data cap is an unpleasant experience for consumers. It is therefore important that the definition of "advanced" telecommunications services necessarily means consumers can *use* the connection without fear of being charged significant overages or of not being able to find information when needed because of very slow connection speeds.

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[71] *See, e.g.,* Comments of US Cellular, *Eleventh Broadband Progress Notice of Inquiry,* at 15 (Sept. 15, 2015), GN Dkt. 15-191, https://www.fcc.gov/ecfs/filing/60001299496/document/60001324129; Reply Comments of Competitive Carriers Association, *Eleventh Broadband Progress Notice of Inquiry,* at 3 (Sept. 30, 2015), https://ecfsapi.fcc.gov/file/60001325933.pdf.

[72] Danielle Kehl & Patrick Lucey, *Artificial Scarcity: How Data Caps Harm Consumers and Innovation* at 9-11, New America's Open Technology Institute (June 2015), https://static.newamerica.org/attachments/3556-artificial-scarcity/DataCaps_Layout_Final.a7ef6b9029da4dd29324757e5710b903.pdf ("*Artificial Scarcity*") (other examples of harm include the opaqueness of data caps making it difficult for consumers to make informed browsing choices and data caps' disproportionate impact on low-income and minority populations).

For wired connections, any connection with a data cap should not be considered

"advanced." There is little evidence that data caps have any technical justifications over wired

connections, and the most popular argument (congestion management) has been debunked.[73]

For wireless connections, data caps should also factor into the FCC's Section 706 analysis.

Data caps on wireless connections may be justified in certain contexts, given the way the mobile

broadband market has evolved. However, the FCC should closely examine the size of data caps

and the effects of various zero-rating plans on the mobile broadband market to ensure that data

caps are increasing in size over time and providing sufficient capacity for a robust user experience.

Consumers can easily exhaust a low data cap on their wireless device. For instance, 4G LTE

Advanced is capable of 1 Gbps throughput.[74] Even a cap of 10 GB per month could be used up in

the matter of 10 seconds by clicking the wrong button and downloading a large file. That user may

then be cut off from their connection, subject to extremely slow mobile speeds, or may incur

extensive overages. While most wireless plans do not have actual throughput of 1 Gbps at this

time, the possibility makes lower data caps very undesirable. For instance, Verizon offers 2 GB, 4

GB, and 8 GB per month plans.[75] AT&T offers plans starting at 1 GB per month and higher, with

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[73] *Artificial Scarcity*, at 7; Chris Morran, *Another Broadband CEO Admits: Data Caps Have Nothing to Do with Capacity*, Consumerist (June 3, 2016), https://consumerist.com/2016/06/03/another-broadband-ceo-admits-data-caps-have-nothing-to-do-with-capacity; Mike Masnick, *Cable Industry Finally Admits that Data Caps Have Nothing to Do with Congestion*, Techdirt (Jan. 23, 2013), https://www.techdirt.com/articles/20130118/17425221736/cable-industry-finally-admits-that-data-caps-have-nothing-to-do-with-congestion.shtml.
[74] *Understanding 5G*, at 11.
[75] List of Verizon Data Plans, Verizon Wireless, https://www.verizonwireless.com/landingpages/verizon-plan. If you hit your data cap, your data transfer rate is slowed and you can choose to purchase more data. Information about Verizon Data Plans, Verizon Wireless, https://www.verizonwireless.com/solutions-and-services/my-verizon-mobile.

severe throttling after hitting the cap.[76] With the prospect of 1 Gbps connections in the near future,

these data caps are inadequate. Moreover, the effects of data caps are felt even more by low-

income communities and communities of color, which often rely on mobile as their sole or primary

connection to the Internet.[77]

As a result, the FCC should consider imposing restrictions on "advanced"

telecommunications when mobile caps are so low that consumers cannot make reasonable use of

their connection. For instance, the FCC could consider mobile connections with a monthly

allotment of less than 5 GB per person to be not sufficiently advanced under Section 706. While the

average user uses approximately 2.9GB per month as of June 2015,[78] data usage will likely increase

given the new services discussed in detail above.[79] However, regardless of what number the FCC

chooses, that number will have to be continually reexamined and raised to ensure the FCC's

Section 706 inquiry is accounting for increased data usage and the development of more data-

intensive services and applications.

V.   Advanced telecommunications services are not being deployed to all Americans in a reasonable and timely manner.

Taking into account the modifications suggested in these comments, advanced

telecommunications services are not being deployed to all Americans in a reasonable and timely

manner. By the FCC's own statistics, 50/5 connections are unavailable to 12 percent of the

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[76] List of AT&T Data Plans, AT&T, https://www.att.com/shop/wireless/data-plans.html (throttling to 2G speeds, or a measley 128 kbps).
[77] *Artificial Scarcity*, at 10.
[78] The average smartphone user uses 2.9 GB of data per month. Kara Brandeisky, *Here's How to Figure Out How Much Cellphone Data You Need*, Time (June 18, 2015), http://time.com/money/3920131/cellular-data.
[79] Relatedly, data caps may be artificially reducing this number, and with higher data allotments, mobile data usage may increase.

population.[80] The number is likely much higher when taking into account the faster upload speed of 20 Mbps suggested in these comments. The additional latency and data cap requirements will likely further reduce the percentage of Americans who have access to truly advanced telecommunications services.

Even using current definitions, it is difficult to argue that advanced telecommunications services are being deployed in a reasonable and timely manner when 10 percent of the country's population still lacks access to those services.[81]

CONCLUSION

Technology has continued to evolve and improve, and the FCC's benchmarks for its Section 706 analysis should reflect those improvements. With increased speed benchmarks and the establishment of latency benchmarks, advanced telecommunications services are not being deployed in a reasonable and timely manner to all Americans.

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Respectfully submitted,

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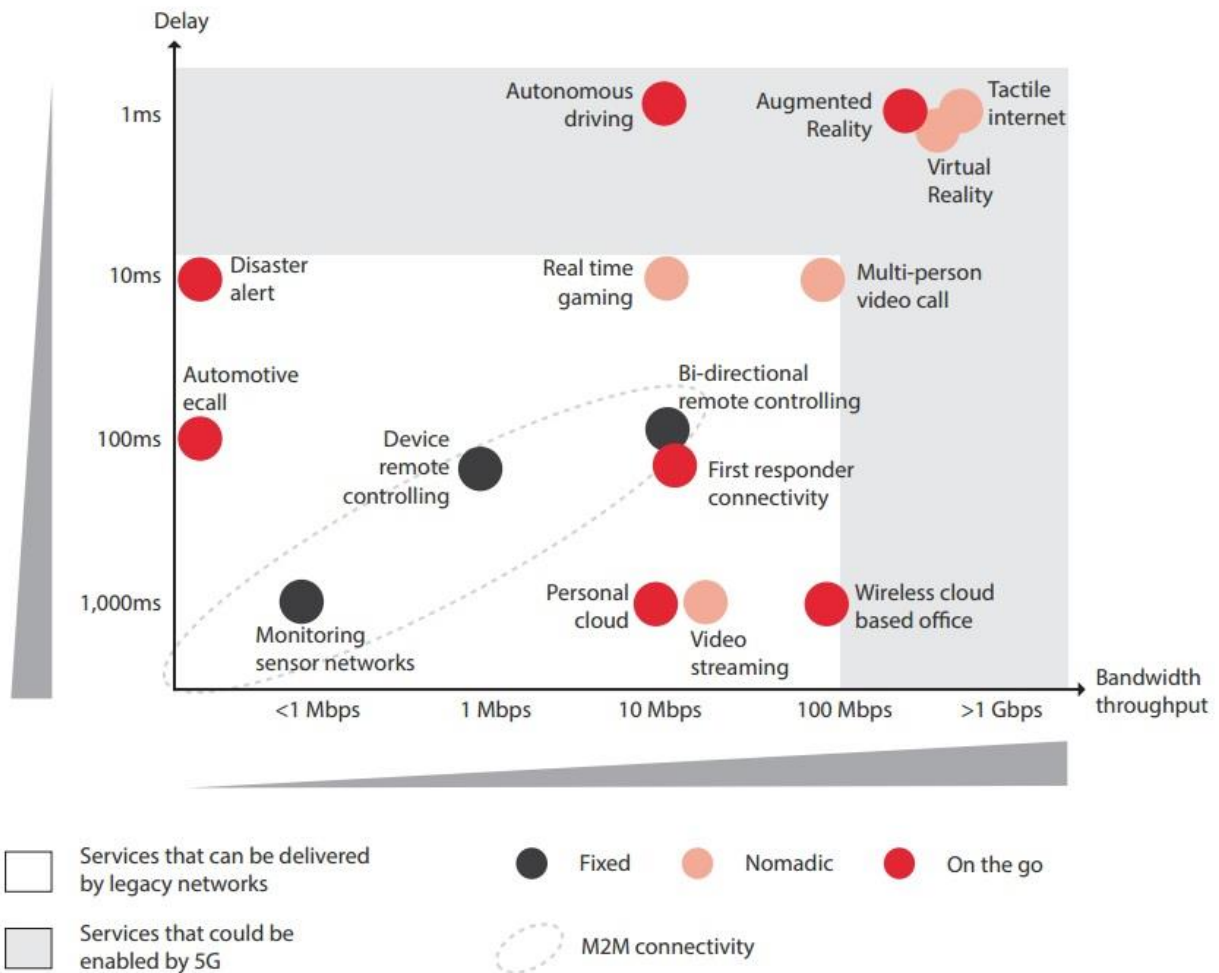
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[80] NOI, ¶ 15.
[81] NOI, ¶ 2.

Figure 1: Bandwidth and latency requirements of potential 5G use cases

Source: GSMA Intelligence

NOTE: This chart is taken from *Understanding 5G: Perspectives on Future Technological Advancements in Mobile* at 9, GSMA Intelligence (Dec. 2014), https://www.gsmaintelligence.com/research/?file=141208-5g.pdf&download.